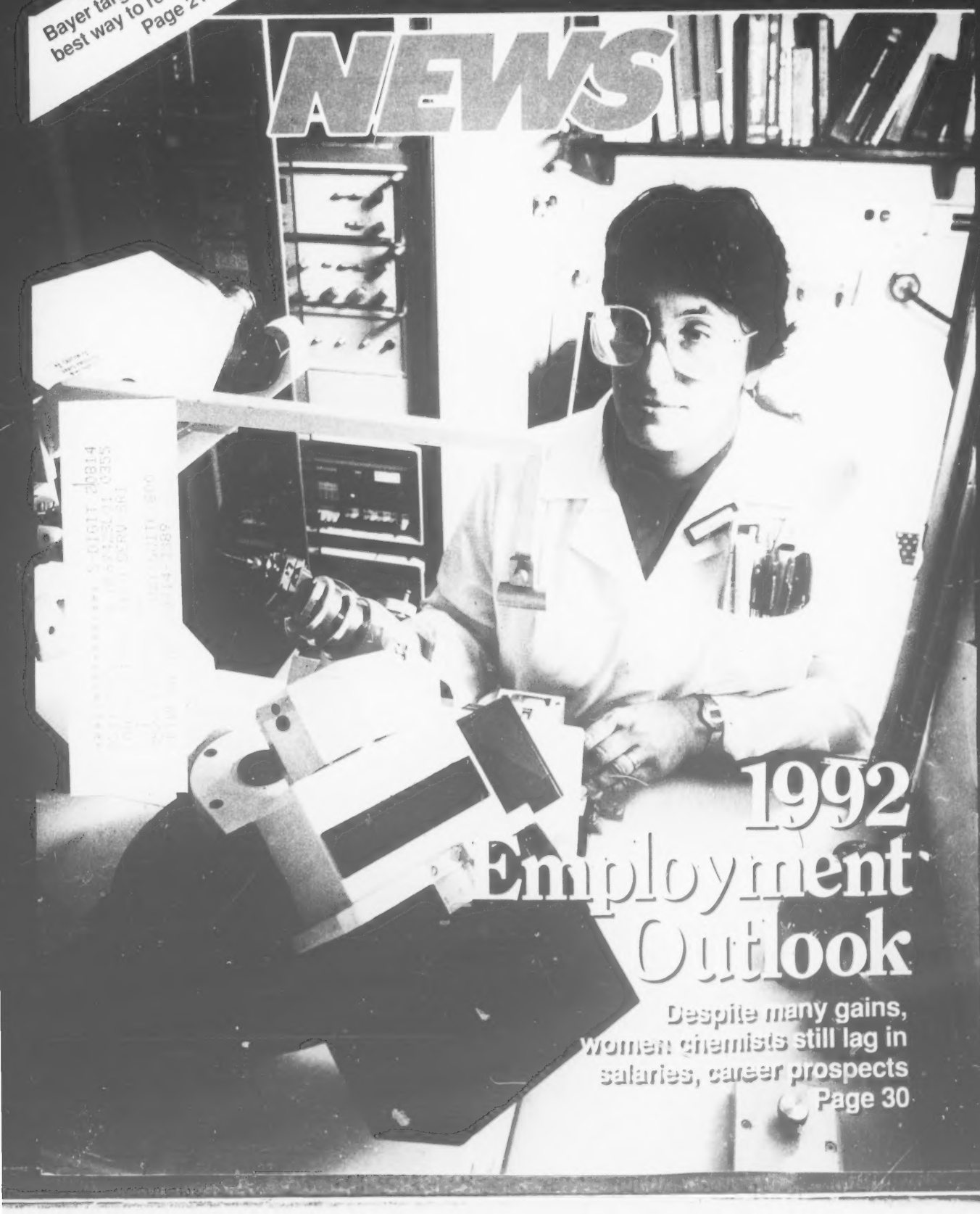
OCTOBER 21, 1991
CHEMICAL & ENGINEERING NEWS

Bayer targets prevention as best way to reduce pollution
Page 21



1992 Employment Outlook

Despite many gains, women chemists still lag in salaries, career prospects
Page 30

Volume 69, Number 42
CENEAR 69 (42) 1-68
ISSN 0009-2347

CHEMICAL & ENGINEERING
NEWS
OCTOBER 21, 1991

News of the Week

- **Swiss physical chemist Richard Ernst has won the Nobel Prize in Chemistry for his methodological developments in nuclear magnetic resonance spectroscopy.** Page 4
- **Nobel Prize in Physics has been given to French theorist Pierre-Gilles des Gennes for work on behavior of complex chemical systems during the transition from ordered to disordered states.** Page 5
- **Fullerenes include carbon-cage molecules that are much more complex than the perfectly symmetrical prototype, C_{60} (buckminsterfullerene).** Page 5
- **Hubble Space Telescope yields its first true-color photograph of the planet Jupiter.** Page 6
- **Dow Chemical has set up an international panel of outside experts to advise its top officials on environmental, health, and safety issues.** Page 6

Cover: Photo courtesy of NIH

Letters 2

Concentrates
Business 7
Government 14
Science/Technology 20

The Departments
Software/Database Update 29
ACS News 46
Newscripts 68

Business

Concern over environmental, economic problems in Eastern Europe are causing chemical firms to think twice about investing there. **Page 10**

More chemical companies are turning to quality programs to assess, manage, and improve their R&D performance. **Page 11**

Healthy growth lies ahead for water treatment chemicals, according to a recent market study. **Page 12**

Government

Joint research efforts are being explored by a Japanese high-tech agency and three Tennessee institutions. **Page 17**

World Bank claims significant progress in its environmental efforts but so far environmental groups aren't impressed. **Page 19**

Science/Technology

Germany's Bayer targets process modification as way to manage pollution-causing products of chemicals manufacture. **Page 21**

First in-vivo catalysis by catalytic antibody is achieved by reseachers at Scripps Research Institute. **Page 27**

Fluorescent dyes attached directly to DNA probes are ready to market for chromosome "painting." **Page 28**

Awards

ACS award winners: Ibers, Klemperer, Kobata, Kubota, Langer, Lenz, Lieber, May, McCall, and Munson. **Page 49**

Employment Outlook

C&EN's annual look at the job market focuses on women chemists—more are choosing chemistry as a career but few are able to break into the top ranks. **Page 30**

Chemical & Engineering News
1155—16th St., N.W., Washington, D.C. 20036
Editor: Michael Heylin
Assistant Managing Editors: James H. Krieger, Janice R. Long, Donald J. Soisson, William J. Storck
Staff Editor: Ernest L. Carpenter
Senior Editors: New York: Earl V. Anderson, Stephen C. Stinson, Chicago: Joseph Haggin; London: Patricia L. Layman; Washington: Doron Dagani, Lois R. Ember, Bette Hileman, Wilbert C. Lepkowski, Rebecca L. Rawls, Pamela S. Zurer
Associate Editors: Stuart A. Borman, Mairin B. Brennan, Ann Marie Menting, Richard J. Seltzer
Service Departments Editor: Dolores Miner
Editing Services: Arlene Goldberg-Gist (Head), Rita E. Johnson (Editorial Assistant), Patricia Oates (Administrative Assistant)
News Bureaus: Northeast News Bureau: (908) 906-8300 Marc S. Reisch (Associate Editor), Ann M. Thayer (Associate Editor), Rachel Eskenazi (Administrative Assistant). Chicago: (708) 256-4143 Ward Worthy (Head). Houston: (713) 973-8161 Bruce F. Greek (Head), Susan J. Ainsworth, (Associate Editor). Washington: (202) 872-4495 David J. Hanson (Head). West Coast: (415) 653-3630 Rudy M. Baum (Head). **Foreign Bureau:** London: (01) 540-0414 Dermot A. O'Sullivan (Head)
Graphics and Production: Leroy Corcoran (Head), Barbara Fryer (Art Director), Linda Mattingly (Staff Artist), Diane Kelly (Costing)
Composition Systems Administrator: Vincent L. Parker. **Assistant:** Robin L. Shapiro
Business Manager: Arthur Poulos
Circulation Director: David Schulbaum
ADVISORY BOARD: Dexter F. Baker, George M. Bodner, F. Peter Boer, Will D. Carpenter, Renée G. Ford, Ethan C. Galloway, Louis J. Glunz, Kenneth G. Hancock, Harry S. Hertz, Christopher T. Hill, Kendall N. Houk, Cynthia A. Maryanoff, Linda B. McGown, C. Bradley Moore, George B. Rathmann, David A. Shirley, Peter H. Spitz, Barry M. Trost
Published by
AMERICAN CHEMICAL SOCIETY
(202) 872-4600; TDD (202) 872-4432
John Kistler Crum, Executive Director
Robert H. Marks, Director, Publications Division
PUBLISHING BOARD: Jeanne M. Shreeve *(Chairman); Board of Directors Chairman:* Joseph A. Dixon; *President:* S. Allen Heininger; Richard L. Deming; William P. Jencks; Gary J. Long; and Louis D. Quin
Subscription & Member Record Service: Send all new and renewal subscriptions with payments to: ACS, Dept. L-0011, Columbus, Ohio 43268-0011. Correspondence and telephone calls for changes of address, claims for missing issues, subscription orders, status of records and accounts should be directed to: Manager, Member & Subscriber Services, ACS, P.O. Box 3337, Columbus, Ohio 43210; (800) 333-9511 or (614) 447-3776.

For changes of address, include both old and new addresses with ZIP code numbers and mailing label from a recent issue. Allow four weeks for change to become effective. Claims for missing numbers will not be allowed if loss was due to failure of notice of change of address to be received in the time specified; if claim is dated (a) North America: more than 90 days beyond issue date, (b) all other foreign: more than one year beyond issue date; or if the reason given is "missing from files."

Subscription Rates 1991: Printed editions: nonmembers U.S. 1 yr. $95, 2 yr. $171; outside U.S. 1 yr. $131, 2 yr. $243. Air freight rates available on request. Rates above do not apply to nonmember subscribers in Japan, who must enter subscription orders with Maruzen Co. Ltd., 3-10 Nihonbashi 2-chome, Chuo-ku, Tokyo 103, Japan. Tel: (03) 272-7211. Single copies: Current $12. Rates for back issues and volumes are available from Microforms & Back Issues Office, ACS, 1155—16th St., N.W., Washington, D.C. 20036. Back and current issues available on microfilm and microfiche. Rates on request from Microform Program, ACS.

Chemical & Engineering News (ISSN 0009-2347) is published weekly except for the last week in December by the American Chemical Society at 1155—16th St., N.W., Washington, D.C. 20036. Second-class postage paid at Washington, D.C., and additional mailing offices. POSTMASTER: Send address changes to Chemical & Engineering News, Membership & Subscription Services, P.O. Box 3337, Columbus, Ohio 43210. ACS assumes no responsibility for the statements and opinions advanced by the contributors to its publications.

Advertising Management: CENTCOM LTD.
(For list of offices see page 67)
Office of Ombudsman: (800) ACS-5558, No. 8-5
© Copyright 1991, American Chemical Society
Canadian GST Reg. No. R127571347

LETTERS

Universal symbol for chemicals

When I read John L. Cox's letter (C&EN, Sept. 9, page 2) concerning a universal symbol for chemicals, I began to wonder what in the world use it could be.

Since absolutely everything in the universe is chemical in nature (except for a perfect vacuum, if such a thing exists), what would you label with this symbol? Would everyone go around with the chemical symbol affixed to their hats, shirts, pants, underwear, socks, shoes, and so on? Would reading glasses have to have separate chemical symbols for each chemical component (such as glass, plastic frames, and metal screws)? Would you be able to see through them if they did?

By how much would the gasoline mileage of an automobile decrease if every chemical component had to carry a label with its appropriate chemical symbol? How would we ever round up the world's flora and fauna so that we could properly label them? How would one go about labeling the separate components of air? Or the dissolved chemicals in natural waters? Would the chemical materials used to make the labels themselves have to bear labels? Where would one stop?

Frank L. Pilar
Professor of Chemistry and Chairman
Department of Chemistry
University of New Hampshire

This is in regard to the letter proposing a universal symbol for chemicals. I was taught in high school that that was an Erlenmeyer flask. Has something changed since the mid-1960s?

George W. Richards
Rochester, N.Y.

Faraday's birthday party

I enjoyed the article on Michael Faraday (C&EN, Sept. 23, page 17) and thought you might like to know what we did to celebrate his birthday. The Michael Faraday Laboratories on the campus of Northern Illinois University house the chemistry and physics departments (thus the naming of Faraday Hall was quite appropriate). This year the university's chemistry and physics labs hosted a birthday bash for Mike complete with cake, ice cream, balloons, speeches, a birthday card, and the like. The event included demonstrations of his work and tours of our facilities.

Local press coverage was good, and we even got our president, provost, and dean of liberal arts and sciences to cut the cake and lead the crowd of about 150 in a rousing chorus of "Happy Birthday." The event was well received. I believe that we must take advantage of every opportunity like this to project chemists as real people, and chemistry as an exciting part of our lives.

Robin D. Rogers
Adviser, Chemistry Club
Associate Professor of Chemistry
Northern Illinois University, DeKalb

It was a pleasure to see the thoughtful story on Michael Faraday. Your readers may be interested to know that, in conjunction with the 200th anniversary of Faraday's birth, the Beckman Center for the History of Chemistry has published a pamphlet titled, "Electrochemistry: a Science at the Interface."

The pamphlet includes "200 Years of Development: an Electrochemical Time Chart" suitable for wall display, and a select bibliography of publications on electrochemical history. We would be pleased to send a free copy of the pamphlet to any interested reader of C&EN.

Arnold Thackray
Director, Beckman Center for the
History of Chemistry
3401 Walnut St.
Philadelphia, Pa. 19104-6228

Oversupply of chemists

David Ostfield's letter (C&EN, Aug. 5, page 2) indicates a feeling that an oversupply of chemists is depressing the job market. I recently advertised locally for an entry-level B.S. chemist's position. I received about 20 responses. I did not receive a single reply from a person with a B.S. degree in chemistry.

Most of the responses came from people with other science degrees, such as microbiology, physics, and the like. I had been a professor of chemistry for 11 years before going to industrial positions. I recall that in the 1970s, armies of students were attempting to get into medical school. What ever happened to those people with science degrees who did not get into medical school? Many of

Authorization to photocopy any article for internal or personal use beyond the fair use provisions of the Copyright Act is granted by ACS to libraries and other users registered with the Copyright Clearance Center (CCC), provided that the fee of $2.50 per article copy is paid directly to CCC, 27 Congress St., Salem, Mass. 01970, USA. Copying for other than internal or personal use without express permission of ACS is prohibited. Address requests for customized bulk reprints to ACS Copyright Administrator, 1155—16th St., N.W., Washington, D.C. 20036, or call (202) 872-4367. The CCC Code for C&EN is 0009-2347/91 $2.50.

velopment cycle, results also were seen.

Over the past eight months, IBM has been trying to apply "market-driven quality practices" to its R&D efforts, says A. Frank Mayadas, plans and controls vice president for IBM's research division. A scorecard system has been created to identify key processes and develop measurement mechanisms in R&D. In ranking R&D achievements of its staff, IBM is trying to include its Nobel Prize winners. He admitted IBM has not yet concluded how it will relate its research processes to market interests.

Most managers seemed to agree that exploratory or innovative research efforts are fuzzier areas and fit less easily into the quality process. Quality programs that look to shorten product development cycle times, reduce costs, and respond to market and investor pressures often are at odds with the longer term outlook of exploratory research.

Ann Thayer

Outlook good for water treatment chemicals

Unit price increases and changes in use patterns are adding greatly to the value of chemicals going to the water treatment market. Although physical volume of water treatment chemicals increased at an average annual rate of about 3.1% per year between 1982 and 1990 to almost 28 billion lb, the market value of those products rose at an average annual rate of 6.7% to $2.4 billion, according to Leading Edge Reports, the Cleveland, Ohio-based market research firm.

According to a recent market study by the firm, continued change and healthy growth are in the cards for the remainder of the 1990s. This growth will come from population growth, regional population shifts, and industrial development. Also spurring growth will be increasing concern about water quality and the resulting environmental legislation, government-mandated water standards, and public funding for water treatment.

These factors will spur 3.3% average annual growth in physical volume of water treatment chemicals to about 39 billion lb by 2000. This would mean a projected value of about $4.3 billion, a more than 6% annual growth rate.

The bulk of the water treatment chemical market, in terms of both physical volume and dollar value, is the category of biological action chemicals. This consists of chlorine, inorganic chlorine compounds, other biocides, oxygen, ozone, and fluorides. But the largest volume of these is oxygen. The Leading Edge study indicates that oxygen alone accounted for about 38% of all water treatment chemicals consumed in 1990.

These biological action chemicals represented the fastest growing major category of chemicals used in the

Need Information on the Chemical Industry?

Call the CAS Search Service®

If you're not currently searching online or you have an emergency information need...just ask the question, and our experts will find the answer!

You'll discover how easy it is to receive

- Information for your Premanufacture Notices
- Business information on the chemical industry
- CAS Registry Numbers® to identify 11,000,000 substances
- Patent information—validity, prior art, families or equivalents in other countries
- Or any other information you need from hundreds of online databases worldwide!

We're fast, we're thorough, and we're here to help you.

Mention this ad when you contact Don Stickel at 800-848-6538, ext. 3707; FAX 614-447-3713; or write: CAS Search Service, Chemical Abstracts Service, Marketing, Dept. 48891, P.O. Box 3012, Columbus, Ohio 43210-0012 U.S.A.

CAS SEARCH SERVICE

Growth will speed up for water treatment chemicals

Millions of lb	1982	1990	2000	% average annual change 1982-90	1990-2000
Coagulants	2,324	2,988	2,985	3.2%	0.0%
Filter media	926	1,335	2,115	4.7	4.7
Neutralizers & salts	10,513	10,114	11,910	−0.5	1.6
Biological action chemicals	8,133	13,472	21,580	6.5	4.8
TOTAL	**21,896**	**27,909**	**38,590**	**3.1%**	**3.3%**

Source: Leading Edge Reports

1982-90 period, with consumption increases averaging 6.5% annually in physical volume and 8.4% per year in dollar value. Rapid growth is expected to continue through the 1990s.

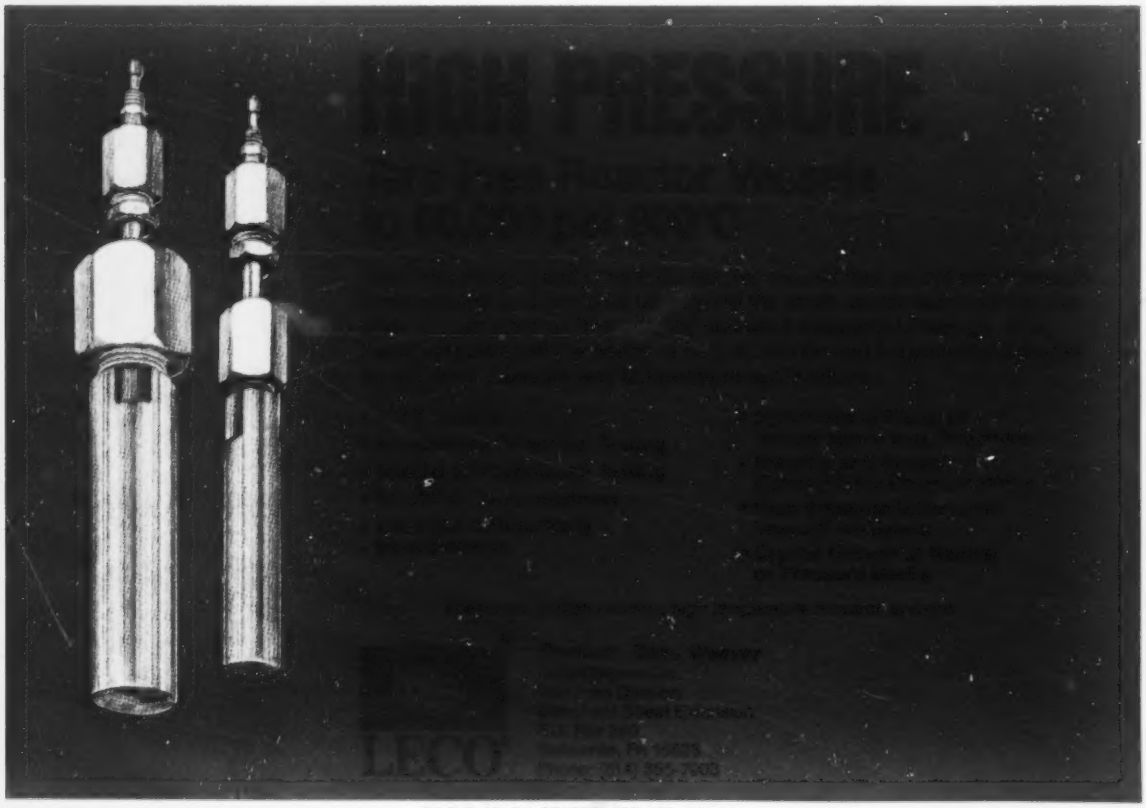
Neutralizers—lime, caustic soda, soda ash, and acids—and salts, are the second largest category with 36% of total volume in 1990, but only 22% of dollar value. The study says neutralizer consumption is being adversely affected by changes in other treatment categories, as well as by shifts in product preference within the category.

Coagulant volume peaked in the mid-1980s and then began to decline, but market value grew 6.8% annually from 1982 through 1990. This growth in market value was attributable to rising use of organic polymer-based coagulants and coagulant aids, which increased in dollar volume at an annualized rate of 13% in a number of treatment applications. All products, except alum, registered strong growth in the 1980s. Alum, however, showed generally flat demand and soft prices throughout the period.

Consumption in the final major market category, filter media—activated carbon, ion exchange resins, diatomite, perlite, and membrane medium—increased 4.7% by weight and 6.4% by dollar value annually during 1982-90. The study finds that, based on market value, this category will represent the fastest growing segment during the remainder of the 1990s, with growth expected to average 7% per year. However, physical volume growth of filter media will only match that of the previous period at 4.7%.

The report, titled "Water treatment chemicals and equipment: Outlook for the 1990s," is available from Leading Edge Reports, 12417 Cedar Rd., Suite 29, Cleveland Heights, Ohio 44106.

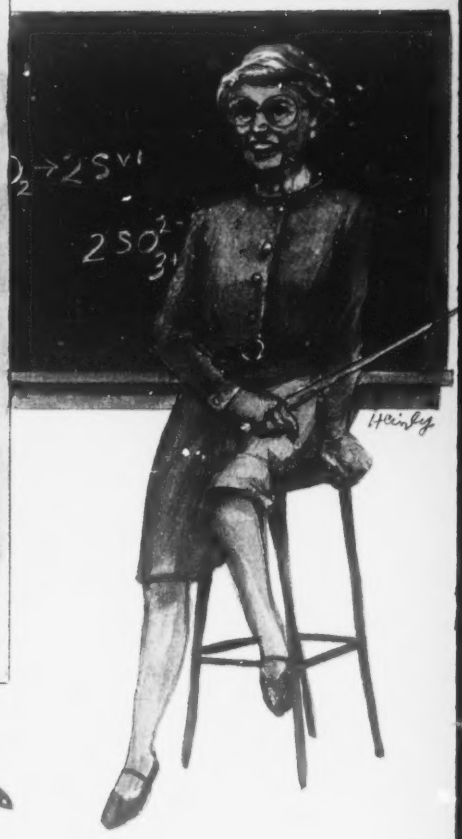
William Storck



CIRCLE 23 ON READER SERVICE CARD

1992 Employment Outlook

Bette Hileman and **Rebecca L. Rawls,** C&EN Washington



Growing numbers of women drawn to chemistry careers, but few reach top ranks

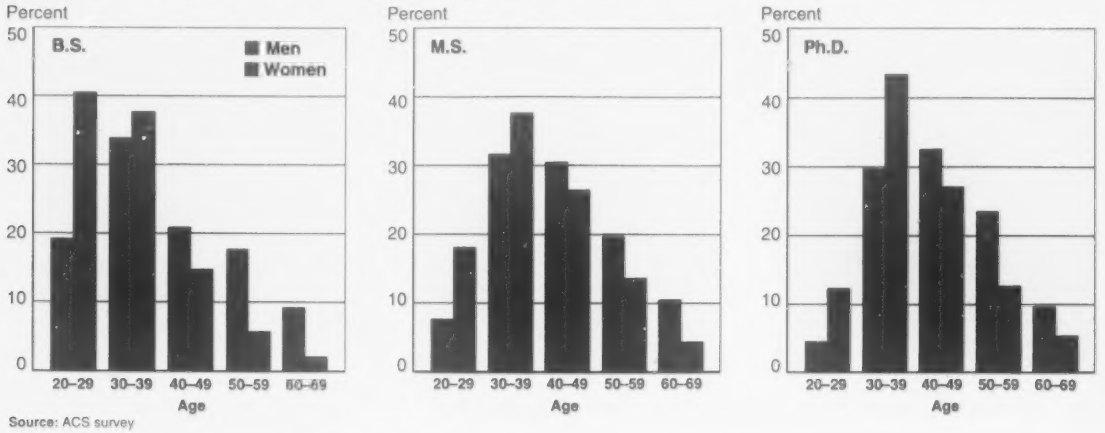
By a number of measures, the profession of chemistry is attractive to women. Since 1970, more than 60,000 women have earned bachelor's degrees in chemistry, receiving some 28% of the total number of these degrees awarded. And the proportion of B.S. degrees going to women increases almost every year, from 18% in 1970 to 39% in 1989, the most recent year for which these statistics are available.

According to a National Science Foundation survey, 35,300 women chemists were employed in 1988, 18% of all employed chemists. In 1978 a similar survey found less than half that many employed women chemists—15,100, or 11% of all employed chemists. By comparison, during that decade, the number of men employed as chemists grew 27%.

In fact, almost every measurable trend shows that women, over time, are making gains toward equity with men in chemistry—gains in their numbers, their pay, and their work responsibilities. Women are moving toward equity, but they still have a long way to go.

Probably the best data available on the current status of women chemists in the U.S. are those col-

Regardless of degree, greater percentage of women chemists are under 40



Source: ACS survey

lected by the American Chemical Society. Every five years, beginning in 1975, ACS has analyzed its annual survey of the salary and employment of its members in an attempt to evaluate and report on the particular status of women chemists. The most recent of these reports is based on a 1990 survey of all ACS members who live in the U.S., are not older than 70, and are neither students nor retirees. It finds a number of differences between women and men chemists, though the magnitude of the differences is frequently less than it was five, 10, or 15 years ago.

For example, women members tend to be younger. The survey found 40% of bachelor's-level women chemists are less than 30 years old, compared with 19% among bachelor's-level men chemists. More than one fourth (27%) of men but only 8% of women with bachelor's degrees in chemistry are older than 50. The relative youth of women chemists may reflect, at least in part, the increasing proportion of chemistry degrees that have been going to women in the past decade. But if women are more likely than men to become dissatisfied with chemistry as a profession, so that, over time, they leave it in larger numbers, that, too, would contribute to the higher percentage of younger women chemists.

Women are less likely than men to have advanced degrees—39% of the women have doctorates, compared with 63% of men. To some extent, this difference is simply a consequence of so many women in the survey being too young to have yet earned a Ph.D. But at every age level women are less likely than men to have a doctorate. The difference is smallest in the 60 to 69 age group, where 53% of the women and 63% of the men have Ph.D.s.

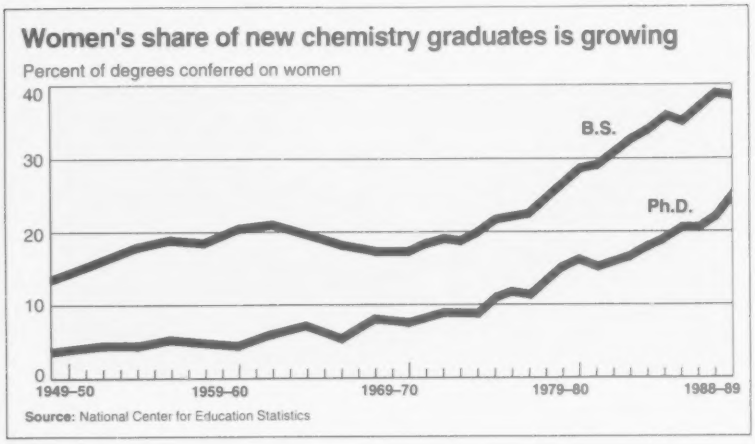
In 1980, nearly half (49%) of women with doctorates worked for academic institutions, compared with 35% of men with comparable degrees. By 1990, the fraction of women employed at universities and colleges had dropped to 39%, while the fraction of men, at 33%, had stayed essentially constant over the period. A similar shift is taking place in the employment of chemists by federal, state, and local governments. The proportion of women finding employment here has dropped from 17% of all women in 1980 to 14% in 1985 to 10% in 1990. About 9% of men chemists worked for governments in 1990, a level that has remained fairly constant over the decade.

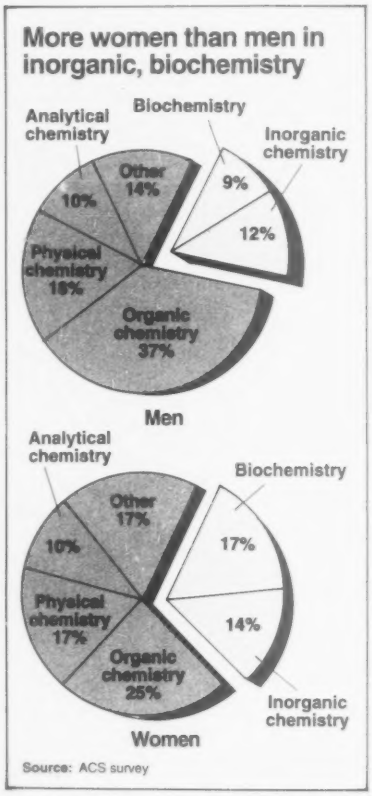
In 1990, 58% of all women chemists worked in industry, essentially the same as the 60% of men who did so. Roughly half the men chemists working in industry have Ph.D.s—50% in the 1980 survey and 54% in 1990. Here, too, the statistics for women are becoming more similar to those of men, with 29% of women in industry having Ph.D.s in 1990, compared with 19% in 1980 and 24%

For women, but not men, salaries stop rising midway through their careers in industry

Years since B.S.	Bachelor's		Master's		Ph.D.	
	Men	Women	Men	Women	Men	Women
0–1	27,330	26,550	—	—	—	—
2–4	29,415	29,000	33,450	$33,000	—	—
5–9	35,000	33,000	36,840	35,820	$47,000	$46,530
10–14	41,500	37,500	43,450	43,000	52,000	50,300
15–19	45,550	41,340	48,800	46,000	59,200	57,793
20–24	50,000	44,916	53,000	48,000	65,250	60,000
25–29	54,600	41,650	56,000	46,150	72,000	60,000
30–34	56,320	44,034	60,000	45,000	73,000	58,200
35–39	57,000	44,330	61,660	51,000	76,000	62,000

Source: ACS survey





in 1985. However, women chemists in industry are much younger than their male counterparts—30% of them are in their 20s, compared with 9% of men. Similarly, only 27% of women in industry are 40 or older, compared with 56% of men.

Women are more likely than men to work for companies outside of manufacturing or for firms that make pharmaceuticals, biochemical products, and soaps. They are less likely than men to work for the relatively higher paying companies that manufacture plastics, specialty chemicals, or rubber. And they are much less likely to be managers. For both men and women chemists, the most likely type of work is applied research—38% of each sex indicate this is their primary work function. For men, the second most likely task is R&D management, which is the primary work of 18% of them. Only 7% of women are R&D managers—much more common functions are production work (14%) and basic research (13%).

About 20% of women chemists in nonacademic jobs accept positions where they see little possibility for professional advancement. This fraction has held constant through the 1980, 1985, and 1990 surveys. The surveys indicate, however, that the number of men who take such jobs is rising. In 1980, 15% of men in their first year on the job felt they had little chance to advance professionally, in 1985 19% thought so, and in 1990 23% held that view.

Once on the job, women's perceptions of their opportunities are improving. At any time, younger women are more likely to see chances for advancement than older women. And once they get five or more years beyond the bachelor's degree, more women at every stage in their careers were optimistic about their prospects in 1990 than had been the case in 1980. In addition, since 1980, the fraction of women 35 to 39 years beyond their bachelor's degrees who see little chance for their own advancement has been going down—from 46% in 1980 to 37% in 1990.

In 1990, nonacademic women saw their chances to become managers as much the same as their chances for professional advancement—about 20% of those within a year of their bachelor's degrees felt they had little chance to become managers, and this fraction rose with age to 39% of those 35 to 39 years beyond their bachelor's degrees. These numbers are down substantially from the 1980 survey, when 30% of women in the first year past their bachelor's degrees thought they had little chance to become managers, more than half of all women 20 or more years past the bachelor's degree thought so, and two thirds of women 35 to 39 years beyond the bachelor's degree held this view. There is no clear pattern for men.

Although their expectations seem to be changing, women don't seem to be actually making much headway in moving into R&D management positions. In 1980, 7% of women chemists in industry were R&D managers, the same percentage as in 1990. Twenty percent of men chemists in 1980 were R&D managers, compared with 18% a decade later. Relatively few chemists of either sex are general managers. For both men and women, this fraction dropped very slightly from 1980 to 1990, so that in 1990, 4% of women were general managers, compared with 5% in 1980. For men, the change was from 8% to 7%.

In 1990, the salaries of women chemists just beginning their careers in industry were generally the same as men chemists. As they get older, however, women's salaries climb more slowly than those for men. Even when adjusted for age, experience, degree, type of employer, or work function, older women chemists earn less in industry than men do. For instance, women with Ph.D.s working in the pharmaceutical industry 20 to 24 years after receiving their bachelor's degree earn 92% of what men in the same position do. And although women Ph.D. analytical chemists who are 15 to 19 years beyond their bachelor's degree earn 97% of the salary of comparable

men, the gap widens to 91% for the same work specialty at 20 to 24 years beyond the bachelor's degree. For analytical chemists whose highest degree is a bachelor's, women 15 to 19 years beyond their degree earn 9% less than comparable men; with 20 to 24 years experience, they earn 11% less.

Among academic chemists, too, women have been making some gains relative to men, but the gains are most apparent on the lower rungs of the professional ladder. Important points of comparison for academic chemists are tenure, rank, and salary. By and large, ACS members employed at colleges and universities, whether men or women, have doctorates. Tenure remains more common for men than for women. In 1990, half of women Ph.D. chemists at academic institutions were either tenured or on a tenure track, compared with 75% of men. Of those with the rank of assistant, associate, or full professor, 58% of the women chemists and 80% of the men had tenure.

In the 1985 survey, women chemists held 3% of the full professorships at Ph.D.-granting institutions; in 1990, they held 4%. Altogether, 62% of the men and 55% of women chemists working in higher education in 1990 were working at Ph.D.-granting institutions, compared with 60% of the men and 48% of the women a decade earlier. Women are much more likely than men at these institutions to be instructors or in nonfaculty positions, and it's unclear whether they are gaining or losing ground in this area. In 1980, 30% of women and 8% of men held such positions; in 1985 these fractions had risen for both men and women to 50% and 16%, respectively. In the 1990 survey, women had dropped back to 39%, while the fraction of men serving as instructors or in nonfaculty jobs remained at 16%.

The way men and women faculty members spend their job time is becoming more similar. In 1985 nearly half (46%) of women faculty spent at least three fourths of their time teaching, compared with one third of men chemistry faculty who did. About 10% of women and 8% of men spent at least three quarters of their time on administration, and 5% of women and 3% of men were full-time researchers. Last year, 37% of women chemists and 30% of men spent three quarters or more of their time teaching, 6% of both sexes spent at least three quarters of their time on administration, and 17% of women and 11% of men spent all of their time doing research.

As in industry, the ratio of women's to men's salaries in academia has increased overall since 1980, but as faculty get older, the gap between women's and men's salaries widens. For full professors, women in 1990 earned 90% of what men did, even among older faculty. A decade earlier, women professors earned between 80 and 90% of what their male colleagues earned, depending on their age. At the associate professor level in 1990, women's salaries relative to men's move downward with age from being equal with men's 10 to 14 years beyond the bachelor's degree to being only 80% of men's for those 35 to 39 years beyond the bachelor's degree. In 1980, the transition was more abrupt, with women dropping from making salaries that were 97% those of men 20 to 24 years beyond the bachelors to 80% of men's 25 to 29 years beyond that degree.

Starting salaries of women assistant professors are not keeping pace with those for men. In 1980, women started at 103% of men's salaries; by 1985, they were starting at 97% of men's salaries; and in 1990, their starting salaries had dropped to 94% of men's. This gap comes about not because women's salaries are declining, relative to men's, at comparable institutions, but because more and more women assistant professors are working at schools whose highest degree offered is the master's or bachelor's. Such schools typically pay their assistant professors less

Women chemists tell of frustration, inequality in workplace

If numbers show that, over time, both the status of women chemists and the women's perceptions of their opportunities are improving, the comments of women who participated in ACS's 1990 survey paint a different picture. ACS's latest survey report includes extensive, anonymous quotes from respondents. The picture they paint is one of anger, frustration, and inequality. "Don't read through the comments all at one sitting," advises Kathleen D. Trahanovsky, who chairs the ACS Council Committee on Women Chemists. "That's very depressing." Here are samples:

"I want to believe I have an equal opportunity; however, it is very difficult. I feel I must work 100% harder than my male counterparts for half the credit. I have an example where I saved the company thousands of dollars solving an existing problem and, although I was recognized companywide in an announcement, I did not receive a bonus, just a company sweater. I know in the past male employees contributing this way received financial reward."

"Chemistry remains a profession dominated by males and the male ego. Even in the best of companies, women Ph.D.s are treated as semisecond class citizens among Ph.D.s in terms of responsibility assignments, supervisory assignments, and subordinate assignments. In graduate school, women always had to work much harder and much more to be awarded their degrees; in industry, it is even more so. It seems the intelligence of women Ph.D.s has no weight against the occasional luck of their male counterparts. Is it frustrating? You bet it is."

"Professors still pride themselves on discouraging people from pursuing scientific careers, especially women. My graduate institution has had a large number of gifted women chemists leave school because of this. My year alone, seven women were in inorganic chemistry, only one is left. The others left school or sought degrees in other areas of chemistry that were less discriminatory (that includes me)."

"Although I have observed attempts on the part of industry to treat women chemists more fairly, this appears to be true only for the younger and less experienced ones. Those of my generation, with more years of experience, still suffer from subtle discrimination and no attempts seem to be forthcoming to right previous wrongs."

"The structural discrimination in academics is amazing. It's not attitudes that are so much a problem anymore, since

those have changed a lot over the past two decades. It's institutional rigidity and unintended social messages that hurt. In 20 years I have heard over 2000 departmental seminars in chemistry by visiting lecturers. Two have been by women. I have never had a female instructor in chemistry. My university hired its first woman, in over 100 years, two years ago. These messages do matter."

"Sexual harassment is still a very serious problem in the industrial chemical workplace. Women do not have confidence in their employers to handle the problem and often remain quiet in fear of losing their jobs. There is a definite glass ceiling in most companies for women on both managerial and technical ladders. The career ceiling is often not very much higher than entry level."

"Currently I report to a female director. She earned the position in January 1990. It is the first time my employer has appointed a female director for R&D. My salary lagged behind my male contemporaries until 1980 when I received two promotions and a 30% increase in pay in one year. Recently new employees are starting out at the same pay rate, and sex discrimination at the start has been eliminated. Change is slow, but the changes are positive. I see a positive future for female chemists in industry and I hope I'm around long enough to see what the future holds."

"[There is] a very real problem women face in trying to compete in mainstream academic research. Such a setting is not geared to those of us constrained to make breakfasts and dinners, to put kids to bed, and to be in town, at home, when our kids are growing up (usually during peak tenure-making years). Does that mean women can't contribute to science through academic research? Of course not, in theory, but in practice, yes!"

"I am employed by an international company which has an equal employment opportunity policy. I expect to rise one level. Beyond that, all of the higher echelon is male. I anticipate that this will be the case for many years. I will probably have to become self-employed to pursue higher ambitions. It's called the glass ceiling, you don't see it, but it's there."

"I believe that women in chemistry have not fared well. High positions continue to be dominated by males. It is a boy's world and there seems to be no relief in sight. In my company, there has never been a woman in senior management, even though 50% of the employees are women."

than do Ph.D.-granting schools. In 1985, 30% of women assistant professors worked at B.S.-granting institutions and 28% at M.S.-granting ones. By 1990, these fractions had risen to 43% and 31%, respectively.

In all types of employment, the survey found several common themes: Although salaries have improved for women relative to men since the 1980 and 1985 surveys, salaries for older women continue to be substantially below those of older men, women report a "glass ceiling" that impedes their progress in both professional and managerial advancement, and women express concerns about how to relate careers in chemistry to family concerns, such as the demands of two-career families and child care.

To gain more information as to why women are not moving into the higher ranks of the chemical profession at the same rate that men are, ACS is in the process of collecting data from an age-matched sample of women and men ACS members. This survey, expected to be completed in the first half of next year, will look for connections between career advancement and the perception of discrimination in the workplace as well as the demands of family responsibilities.

The new ACS survey closely resembles one conducted by the Royal Society of Chemistry in 1988. That survey of some 2600 British chemists found different career progression and promotion opportunities for men and women. Half of the women and 65% of the men said they had not encountered sex discrimination at work. For those who had encountered it, the discrimination was much more frequently perceived to be against women.

Nearly one third (30%) of the men and 17% of the women in the British survey thought men had an advantage in obtaining jobs, compared with 1% of men and 8% of women who thought women had the advantage. In the case of promotion, just over one fourth of both men and women thought men more likely to be promoted than women, compared with 2 to 3% who thought women had an advantage here. This perception of a disadvantage in promotion for women was highest (35%) among mid-career women.

Most men (81%) and women (61%) said they had not encountered sexual harassment on the job, but one fourth of the women and 16% of the men said they had encountered it against women (other than themselves). One fourth of the women said they had themselves been sexually harassed at work.

The stresses of dual-career families and of child rearing seem to fall more heavily on women than men in the British survey. Of people living with spouses or partners, more than 90% of both men and women said their partners were supportive of their careers. However, 88% of the men, compared with 47% of the women, said their partner would be willing to relocate to fit in with their careers. Two fifths of the men and half of the women said their careers had been affected by their partner's unwillingness to relocate.

One woman in six in the survey had taken a break in her career. Most often these breaks began when the women were between age 26 and 30, lasted three years or more, and were to take care of children. Child care facilities available at work were not considered adequate to meet the need for them. On returning to work, 44% of the women thought that their job responsibility had deterioriated while they were gone. Only 3% of the men had taken career breaks, and these were usually for less than four months and were for reasons other than taking care of children.

A more detailed presentation and analysis of the survey findings is available in "Women Chemists 1990," which can be purchased for $39.95 from the ACS Distribution Office, Room 210, 1155—16th St., N.W., Washington, D.C. 20036. □

Demand

With several key chemical companies and universities in the midst of cost-reduction programs, recruiting will be down this fall

Demand for chemists and chemical engineers will be down substantially in 1992. Signs of softening were already apparent by the end of September, when this year's recruiting season unofficially began, and most recruiters, college placement centers, and student advisers contacted by C&EN expect the number of entry-level jobs available to shrink a good deal further in the coming year.

The reasons are almost entirely economic. "The U.S. economy overall has been in a recession for a year," explains James D. Burke, manager of professional recruiting for Rohm & Haas. "Prior to that, we had eight years without a recession. Companies have overextended their research staffs. Now they will need to be very conservative about hiring" to get through these leaner economic times, Burke predicts. "Nobody wants to have layoffs," he adds.

Yet some positions for chemical professionals already have been terminated and, almost certainly, the coming year will bring more. Many major chemical producers—among them Monsanto, Du Pont, Union Carbide, Allied-Signal, Arco Chemical, Hercules, Occidental Petroleum, and Phillips Petroleum—have announced (or in some cases completed) major cost reduction programs that include significant reductions in staff size.

Most of the staff cuts will not be from the ranks of chemists and chemical engineers, and by far the largest part of these cuts will be made by not replacing people who choose to leave, either through ordinary retirement or to take advantage of special incentives to do so that companies will be offering. However, several companies have already announced that before it's over, they expect to be terminating some workers. Thus, even the demand for presently employed chemical professionals may decline in the coming year.

Nor is the picture bright for those seeking academic employment. Although an aging faculty makes vacancies produced by retirement more and more common in university chemistry departments, serious budget constraints, particularly at state universities, limit the number of those vacancies that can be filled. And the escalating costs associated with setting up a new assistant professor at a research university are adding to the difficulty of hiring new faculty.

Altogether, 1992 may be the worst year in nearly a decade to be seeking work as a chemical professional. Still, there is recruitment going on, and particularly well-qualified candidates will continue to have their choice of offers in both industry and academe.

At the bachelor's level, the combination of steadily declining class sizes and a rising share of chemistry graduates going on to graduate or professional schools means there are many fewer new graduates looking for jobs than there were in the last recession, which occurred in the ear-

Chemistry bachelor's degrees have declined 26% in past decade, while chemistry Ph.D.s have risen 34%

	Degrees awarded in chemistry			Degrees awarded in chemical engineering		
Academic year	Bachelor's	Master's	Ph.D.	Bachelor's	Master's	Ph.D.
1978–79	11,643	1765	1518	5655	1149	304
1979–80	11,446	1733	1551	6383	1271	284
1980–81	11,347	1654	1622	6527	1267	300
1981–82	11,062	1751	1722	6740	1285	311
1982–83	10,746	1604	1746	7145	1304	319
1983–84	10,704	1667	1744	7475	1514	330
1984–85	10,482	1719	1789	7146	1544	418
1985–86	10,116	1754	1908	5877	1361	446
1986–87	9,661	1738	1976	4983	1184	497
1987–88	9,052	1708	1995	3917	1088	579
1988–89	8,654	1785	2034	3684	1097	599

Source: National Center for Education Statistics

ly 1980s. At midsummer, unemployment among recent bachelor's-level chemistry graduates (those in their first year after graduation) was above 14%, according to ACS's annual starting salary survey, up from 13% the summer before and 10% in the summer of 1989. Unemployment for new bachelor's chemists went as high as 18% in 1983, according to the survey.

These same demographic factors are working against new chemistry Ph.D.s. Graduating classes are a third larger now than they were a decade ago. And unemployment among new Ph.D. chemists, which stayed below 4% throughout the recession of the early 1980s, has risen sharply in recent years. This summer found it over 11%, according to the ACS survey, up from 10% a year earlier.

The picture is more rosy for new chemical engineers. Although the forces that are reducing demand for chemists affect chemical engineers as well, the effects likely will be more moderate. Chemical engineering graduates have been in very short supply and more highly sought after than chemists for the past several years. Compared with chemists, chemical engineers more often are employed in the petroleum industry, which, though feeling the effects of the recession, has not been so hard hit as the chemical industry.

With a major cost reduction program already announced, Du Pont will be recruiting about one fourth the number of professionals it usually does, says Kevin McCormack, manager of professional staffing. This reduction will apply to both chemists and chemical engineers. Many of the positions will be filled by people who already have a relationship with the firm—through cooperative education programs, summer internships, or company-sponsored scholarships. Because there are so few openings, Du Pont will not be recruiting on campuses.

"Historically, we bring in a certain number of new graduates each year to refresh the pipeline and keep our staff well balanced with new ideas," McCormack says. "We won't be engaging in as much of that this year."

In July, Du Pont announced a $1 billion companywide program to reduce fixed costs in virtually all areas outside of manufacturing. The program will last for one or two years and is intended to make the company more competitive. Most of the areas where chemists and engineers work, including fibers, engineering, central research, medical products, and safety, health, and environmental affairs, have announced their restructuring plans in recent weeks.

Although not intended primarily as a personnel reduction program, McCormack says, "there will be people leaving the company, voluntarily, as much as possible." Some employees are being offered incentives in the form of enhanced pensions, lump-sum payments, and seminars in career and financial planning. In addition, people are being redeployed within the company. Most of Du Pont's needs for chemists and chemical engineers in the coming year will be filled by these internal transfers, which already have begun. This includes many of the hiring needs of Du Pont's petroleum operations, which heretofore have recruited separately.

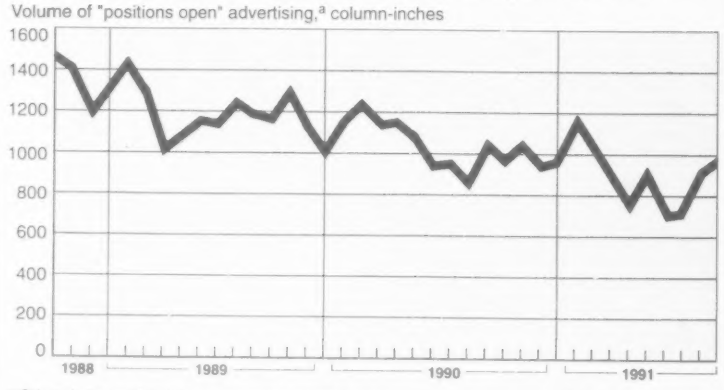
Union Carbide, too, is in the midst of a cost reduction program, which aims to cut costs by $250 million a year by 1994 and to reduce the work force by 5500. Most of these staff reductions—about 3700—already have taken place and probably do not heavily affect the company's chemists and chemical engineers, although they do include some, says Thomas J. Neelen, manager of professional placement.

For chemical professionals, probably the biggest impact is on recruitment, which will be down substantially this year. Carbide will be doing on-campus recruiting this fall and next spring, but, especially at the bachelor's level, the number of positions available will be small. The company will be hiring Ph.D. chemists very selectively, at about half the level of recent years, Neelen says. Hiring will be only a third of usual numbers for bachelor's- and master's-level chemists and chemical engineers, and an increasing fraction of these new-hire positions will be filled by students who have previously worked at Carbide either in co-op education programs or as summer interns.

The company would be shifting to this source of bachelor's-level candidates even if overall needs were not down, Neelen says. Getting to know students fairly well through several months of employment makes for a much better match than can be done through interviewing alone. Not only is Carbide more satisfied with new employees that it gets by this route, but the retention rate also is much higher, indicating the students, too, have had a better chance to evaluate what kind of work they are being hired for and to decide whether it's what they're looking for. Carbide plans to be hiring half of its bachelor's-level candidates from this source within the next few years, Neelen says. Co-op and summer employment oppor-

Help-wanted ads in C&EN continue three-year decline

Volume of "positions open" advertising,[a] column-inches



[a] Column-inches published during consecutive periods of four weeks each; no issues were published in the last week of 1988, 1989, and 1990.

tunities for students have not been cut back this year, he adds.

Even in lean times, "any organization needs to be bringing in new employees," Neelen says. Thus, although the number of job openings is down this year, "it's still critical for the future to be bringing in new chemists and chemical engineers. We do have ongoing annual commitments to do this, regardless of the current economic climate."

Monsanto is in some ways one step ahead of some of the other major chemical producers, in that its restructuring began in late 1990 and is now essentially complete. Three key areas of the company where chemists and chemical engineers work have all had fully subscribed voluntary programs to reduce staff—agriculture, chemicals, and corporate research, explains Robert J. Mason, corporate director of university relations. Now, Mason says, "life has gotten better. Signs indicate the recession has eased off some," and the company plans a full schedule of campus recruiting this year. The need for chemists and chemical engineers will be "basically normal," he predicts, although, as is always the case, hiring plans will be revised early in 1992.

In part, this year's demand is a carryover from last year, when recruitment targets were low, as a result of restructuring. In some areas, last year's incentives to encourage employees to leave were too effective, so some of Monsanto's recruiting this year is to fill vacancies caused by these departures.

Dow Chemical isn't restructuring, but its recruitment will be down this year. The company expects to hire about a third as many chemists and chemical engineers at all degree levels as it usually does, says Smallwood Holloman, manager of mid-East recruiting and college relations. The firm will be making trips to campuses, looking particularly for bachelor's-level candidates, and, as has been the case in recent years, looking hardest for chemical engineers. "We keep getting signals that the recession is over, but we haven't seen a turnaround yet," Holloman says.

Rohm & Haas, like Monsanto, isn't predicting major reductions in its demand for chemical professionals this year. The company will be hiring somewhat fewer Ph.D. chemists than they intended to hire last year, says Rohm & Haas' Burke. Last year the company hired more doctoral chemists than it started out to "because the pool was so good," he adds. As other companies cut back on their Ph.D. hiring last year, Rohm & Haas found itself with a bigger selection of high-quality candidates. Most of this year's reduction is to offset last year's greater hiring. At the bachelor's and master's level, hiring will probably be up modestly this year, principally to provide more support staff for the recently hired Ph.D.s.

Similarly, PPG Industries' manager of professional employment, Joseph Schewe, is cautiously predicting that that company's needs for chemists and chemical engineers will be down only slightly this year. Although budgets are not all in yet, the company is not restructuring and hopes to be hiring to add people to its professional work force. "I don't want to sound too optimistic," Schewe adds. "If the recession keeps on, things could look bad in a couple of months."

Petroleum firms such as Exxon are still recruiting aggressively for chemists and chemical engineers. Hiring targets in both fields have been scaled back about a third at Exxon, but the company's recruiting schedule hasn't been reduced. And particularly for chemical engineers, the company still expects demand to be very high.

At universities, an increasing number of chemistry faculty are reaching retirement age each year, which should mean a healthy demand for new Ph.D. chemists to fill tenure-track positions. But it isn't working out that way, says Paul G. Gassman, professor of chemistry at the University of Minnesota. Particularly at state universities, many of which have been hit by major budget cuts this year, chemistry and other science departments are finding themselves with more vacancies than they have funding to fill. The biggest stumbling block, Gassman says, is the cost to set up a laboratory for a new assistant professor. Setup costs are now in the range of $200,000, an order of magnitude higher than they were 10 years ago.

The departments find themselves in a particularly vicious cycle, Gassman says. Qualified candidates for academic positions are very hard to find, despite the need, he says. And when positions go unfilled for too long, the university is apt to take them away. He cites the example of his own department, which tried unsuccessfully to fill three vacancies last year. Three more faculty have now retired, leaving the department short six positions. However, the university has only authorized hiring for two positions this year.

Minnesota is not alone. The Council for Chemical Research is in the midst of a survey of, among other things, faculty vacancies in chemistry departments at member universities. The 74 departments that have responded so far report they are seeking to fill 103 faculty positions. More than one third of the positions have been vacant for at least a year.

How long will the depressed hiring last? Class size is building up at universities, and so is the pressure to fill the vacancies that haven't already been lost, even if doing so means accepting somewhat lower quality applicants. Quality standards have gotten very high during the recent period of relatively few vacancies and increasing numbers of Ph.D. graduates, and some department chairmen privately acknowledge that these standards may have to come down before current vacancies can be filled. But for now, many departments seem to prefer to increase class size, defer sabbaticals, and keep looking for the kind of junior faculty they want, even if they risk losing the ability to fill their vacancies by doing so.

As for industry, recruiting won't go up until the economy does, and for chemicals, that hasn't happened yet. As is usually the case, many companies will revise their recruitment goals for this academic year sometime in early 1992, after they have their own year-end performance data. But few recruiters are predicting those revisions will go upward. And what the picture will be like a year from now is impossible to tell. "For one or two years it may be bad," is the way Du Pont's McCormack puts it, "but we're not going away." □